CIR Combustion Chamber Design Review

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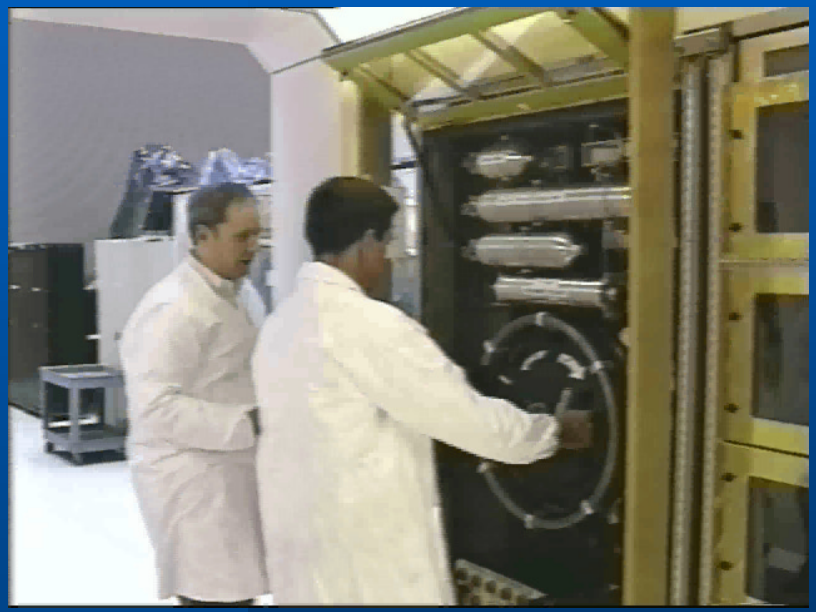
Requirements

- **The following requirements were drawn from the Science Requirements Envelope documents, FCF document number FCF-DOC-002**
  - **The FCF shall provide a combustion chamber with adequate volume and dimensions to accommodate the test sections of basis experiments c1 through c11. Requirements are shown in Figures C1a-b. Compliance shall be verified by analysis and conceptual layouts that show that the FCF, augmented by PI-specific hardware, meets the requirement.**
  - **FCF shall accommodate simultaneous imaging of the test cell from at least two orthogonal directions as required by the basis experiments.**

Requirements (continued)

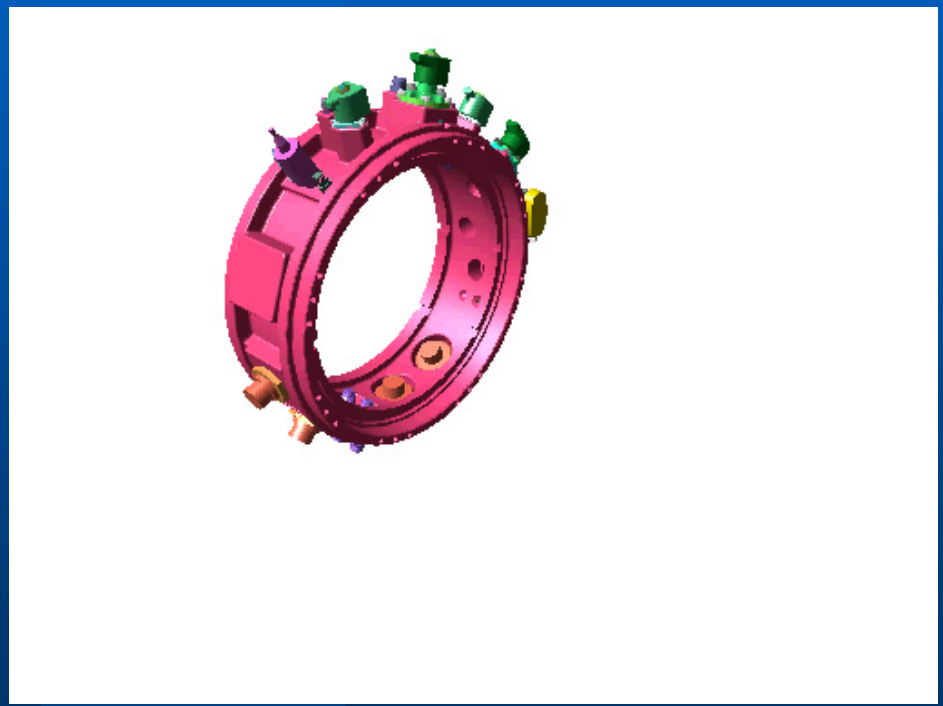
- The FCF shall provide pressure containment and control for initial gas pressures in the range of 0.02 to 3 atmosphere. The FCF shall provide containment and control for the pressure to remain constant within 5% throughout the test time. It shall provide containment for pressure increases to 9 atmospheres (absolute). The FCF shall provide control for initial gas temperatures of 268 to 320 K. Condensed phase fuel temperatures shall be controllable to ±1 K in the range 268 to 315 K at the start of testing. Compliance shall be verified by test and analysis that show that the FCF, augmented by PI-specific hardware, meets the requirement.

General Overview



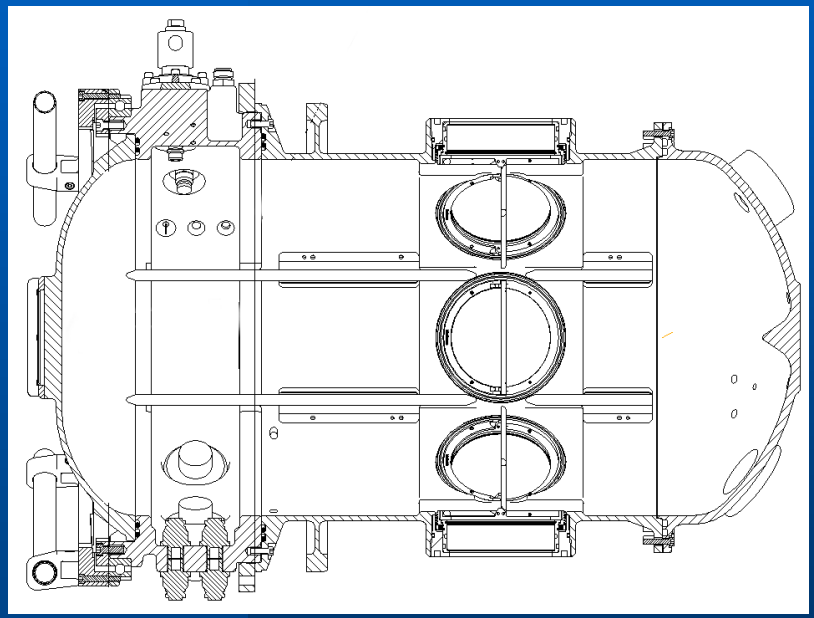
- The CIR combustion chamber is located about waist height to a crew person as shown here.
- It is designed to allow replaceable CIA's to be inserted and removed without using tools, or tethers.

General Overview (continued)



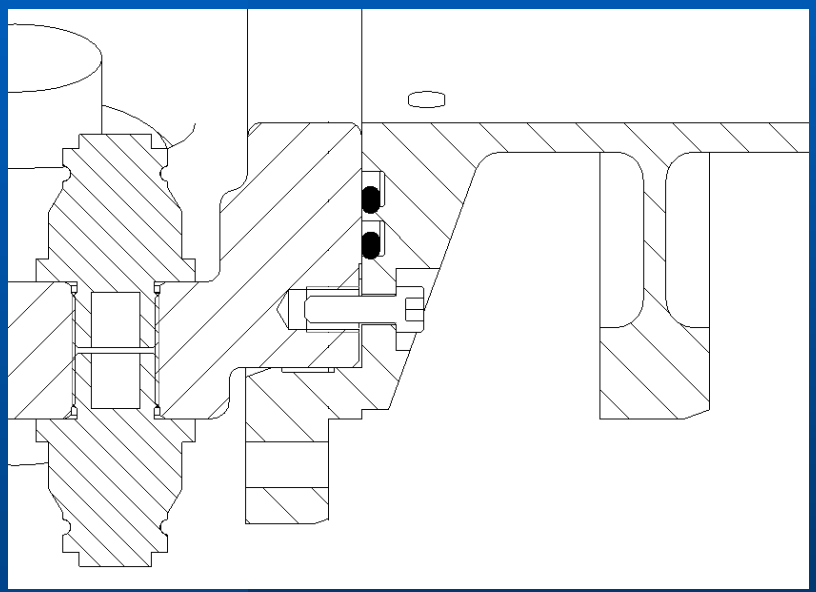
- The CIR Combustion chamber is a 7075-T73 aluminum pressure vessel encompassing a minimum of 101 liters of free volume.
- It has eight 120 mm diameter field of view replaceable windows.
- It is composed of five major sections:
  - Rear end cap
  - Window Section
  - Interface Resource Ring (IRR)
  - Front end cap
  - Breech lock mechanism

General Overview (continued)



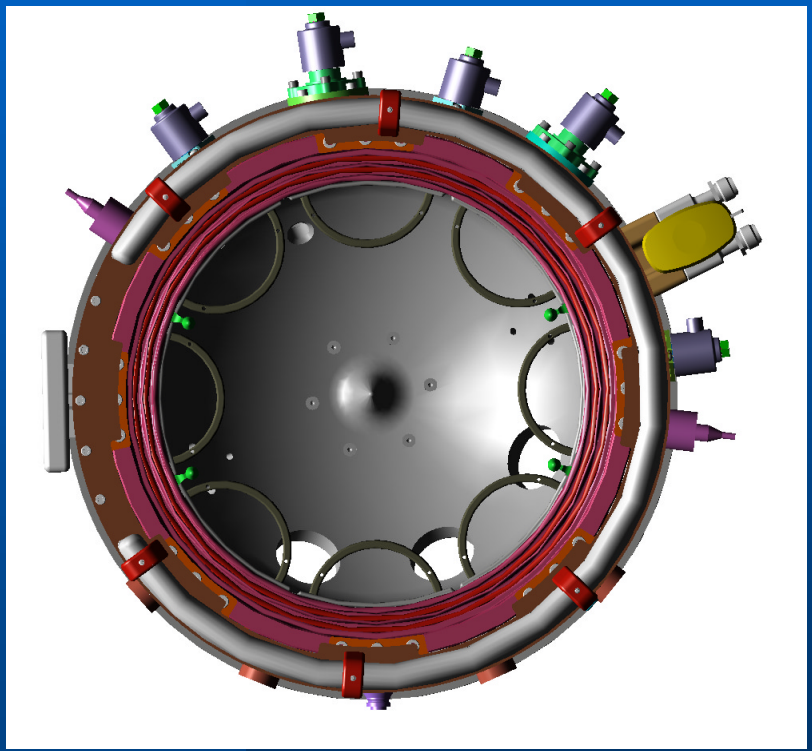
- The chambers Maximum Design Pressure (MDP) is 135 psia.
- It weighs approximately 131 kg.
- It occupies approximately 234 liters of volume in the rack.
- The Interface Resource Ring is located at the front of the chamber and contains all fluid and electrical interfaces, except the filtration loop return.

General Overview (continued)



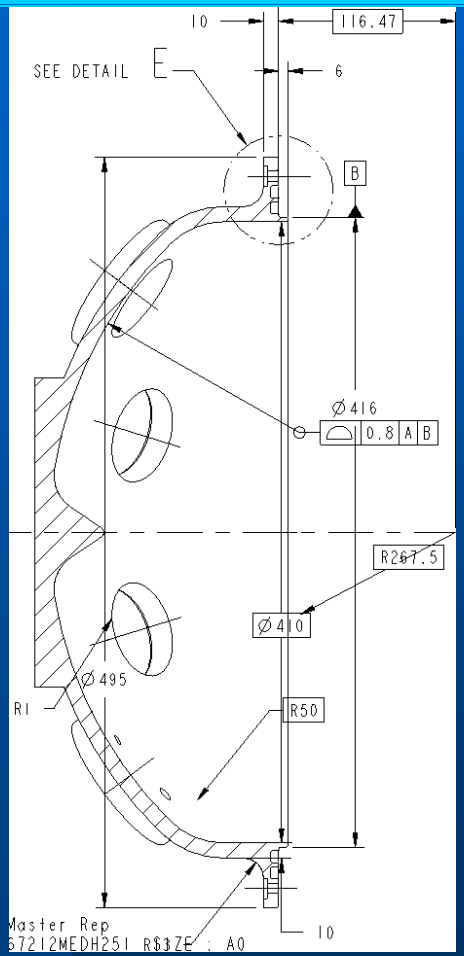
- The chambers uses 15, M8 screws to clamp the Window Section to the chamber mounting ring on the optics plate.
- The area behind the attachment flange on the Window Section and another ring around the chamber will be used to accommodate any shear.
- All fasteners screw into locking Keenserts.

General Overview (continued)



- The chamber is designed to house a CIA with maximum dimensions of 600 mm long, and 396 mm in diameter.
- The furthest a CIA can be inserted into the chamber is the point at which the rear end cap begins to curve.
- The CIA to chamber interface consists of four rails positioned 22.5° above and below the horizontal axis of the chamber. This allows the CIA to utilize all eight windows.

Rear End Cap



- The rear end cap is attached to the window section using 36, M6 screws. A small pilot diameter on the rear end cap allows alignment with the Window Section.
- It utilizes two, 1/4” cross section o-rings to make the seal between it and the window section.
- The flange where the seals are made is 10 mm thick.

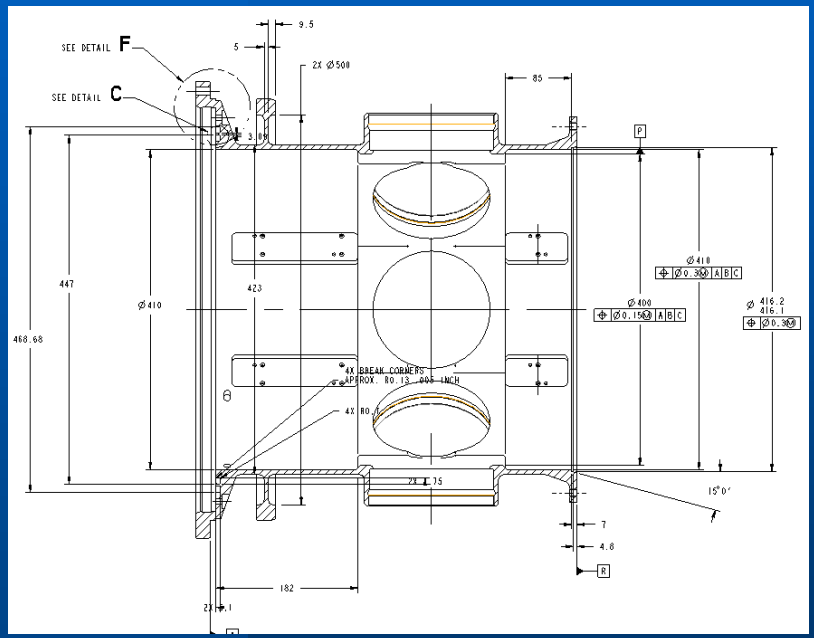
Rear End Cap (continued)

- There are 13 bosses located on the rear end cap, 5 large and 8 small.
- The 8 small bosses are used to mount the pumps utilized in the FOMA filter loop, four bosses to each pump.
- Two large bosses each are machined for a temperature thermister, a pressure transducer, and a pressure switch.
- One of the large bosses is going to used for the fan power feed-through and another for the FOMA filtration loop return valve.

Rear End Cap (continued)

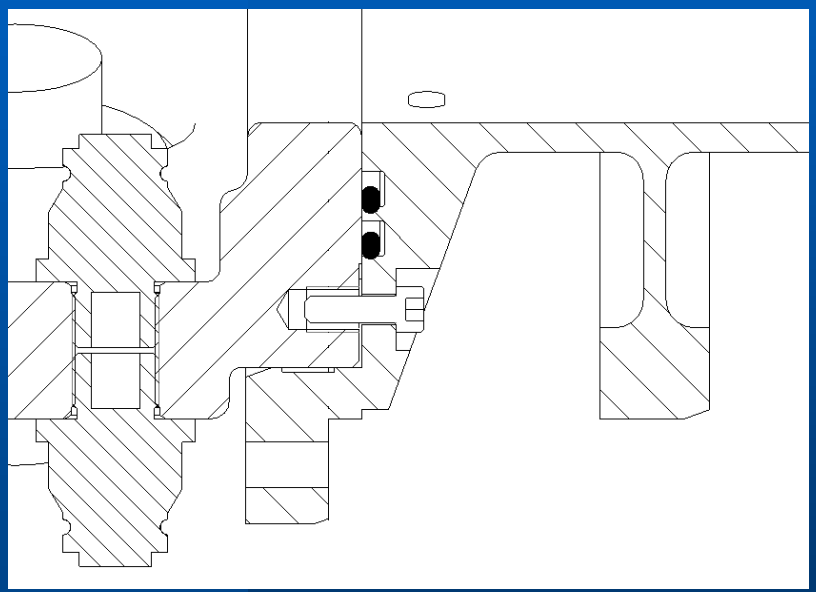
- The inside surface of the rear end cap is a 266.5 mm radius which closely resembles a 2:1 ellipse.
- A protrusion is located in the center of the end cap on the inside and is used to disperse the airflow from the fan evenly.
- Six M5 keenserts are located around the protrusion to mount the shroud for the chamber fan.
- The end cap wall thickness is 6.5 mm thick.

Window Section



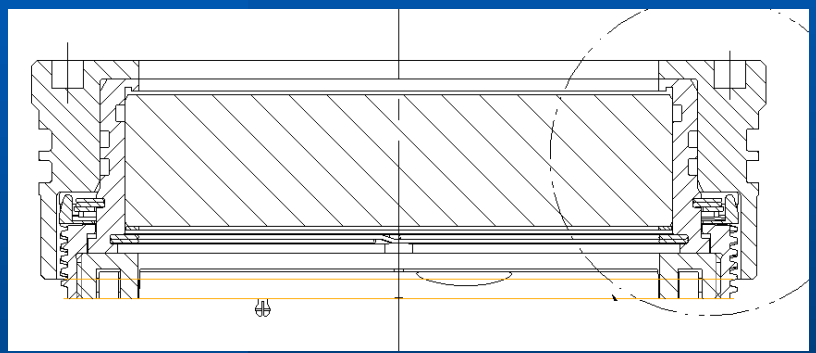
- The window section is 488.4 mm long and 584 mm in diameter at its largest cross section.
- The minimum internal diameter is 400 mm.
- The rear flange is 10 mm thick and contains 36, M6 keenserts for attachment of the rear end cap.
- The main wall thickness of the window section is 6.5 mm.

Window Section (continued)



- The window section has 36 counter-bored through holes sized for M6 screws to attach the window section and the IRR.
- It has 15 through holes sized for M8 screws to attach the entire chamber assembly to the optics bench.
- The area directly behind the mounting flange and the ring located 77.7 mm from the front of the window section help take up shear and locate the chamber.

Window Section (continued)

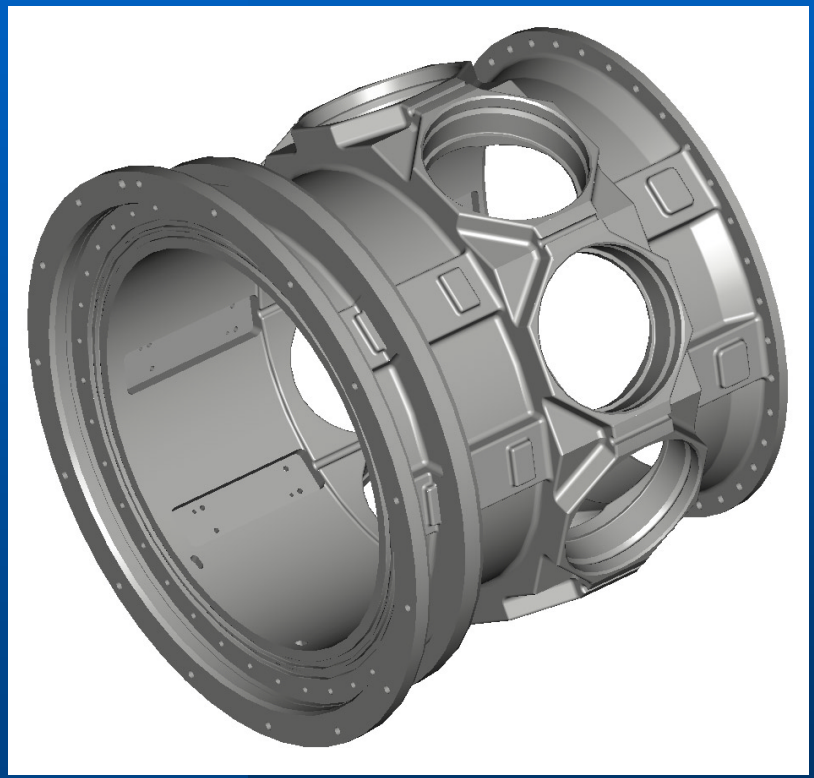


- The window section contains eight locations for replaceable windows.
- Each location is threaded to accept a stainless steel insert to eliminate wear on the aluminum window section.
- The window insert contains two large cross section O-rings which were driven by the phase 0/1 safety review.
- The window locations provide for 4 separate orthogonal views with back lighting.

Window Section (continued)

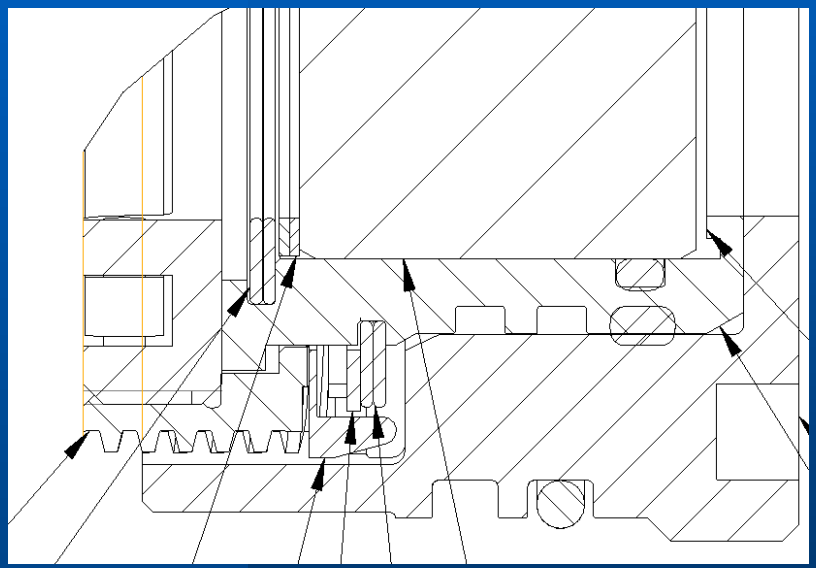
- The window section has recessed areas 22.5° above and below the horizontal of the chamber and on either side of the vertical to accommodate a CIA alignment system.
- The recesses have additional bosses on the outside of the chamber to accommodate the attachment of the alignment system.
- Four slotted holes on the chamber wall locate the CIA with respect to the windows.

Window Section (continued)



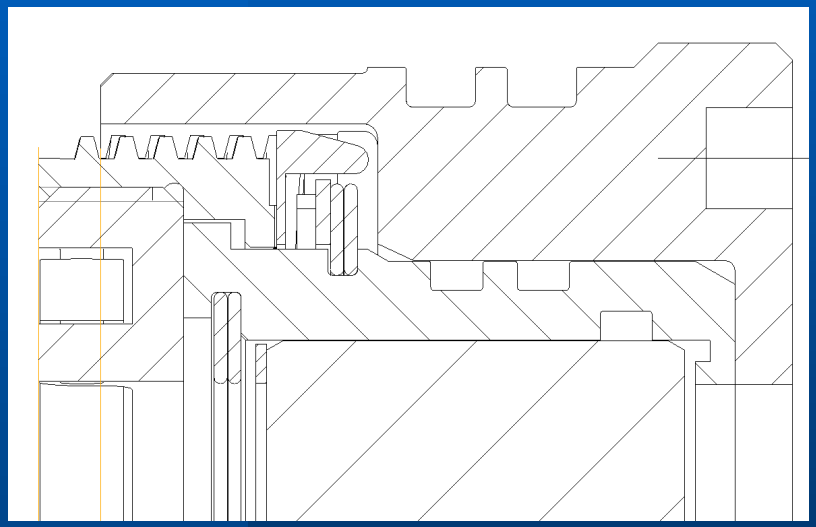
- The window section has a small pocket at the front that acts as a pilot diameter for the IRR.
- The IRR seals to the window using two 1/4” cross section o-rings which was also driven by the phase 0/1 safety review.
- Clearance grooves are present between the windows to accommodate the CIA interface.

Replaceable Windows



- The Replaceable Window uses a triple lead ACME screw to screw into the stainless steel insert.
- The window holder seals against the stainless insert using two o-ring seals as requested by the phase 0/1 review panel.
- The window material seals against the window holder using an o-ring seal and a gasket seal at one end.

Replaceable Windows (continued)

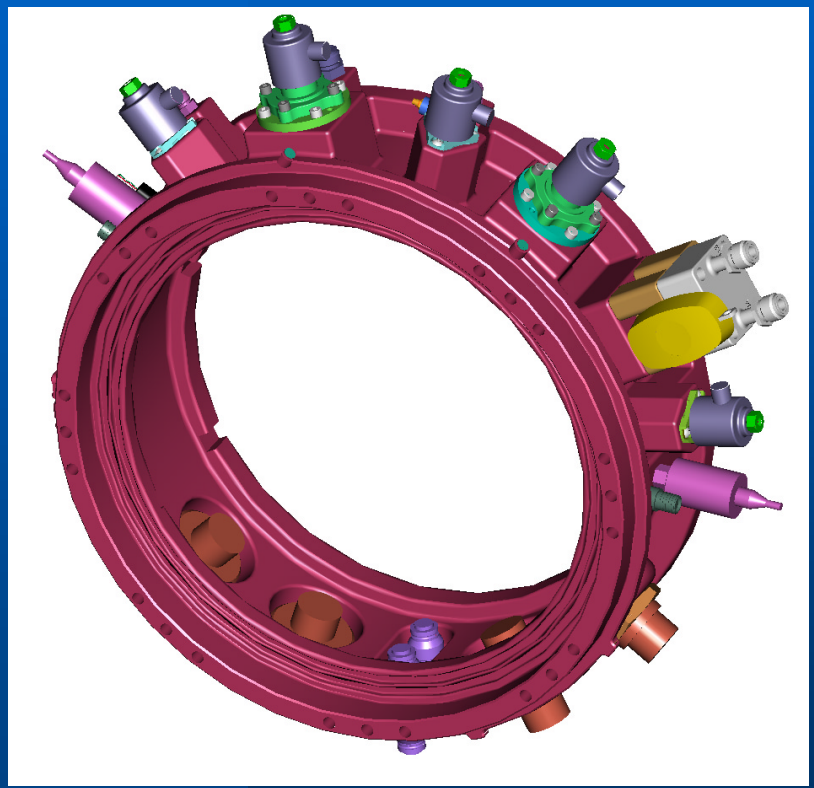


- The window material is held in place using a soft durometer elastomeric attached to a stainless backing pushed into place using a snap ring.
- The ratcheting action of the window is achieved by a serrated profile on top of the ACME screw. A dimple plate is placed on top of the screw, a wave spring is placed on top of the plate, which is in turn held captive by a spring capture ring. This assembly is held in place by another span ring.

Replaceable Windows (continued)

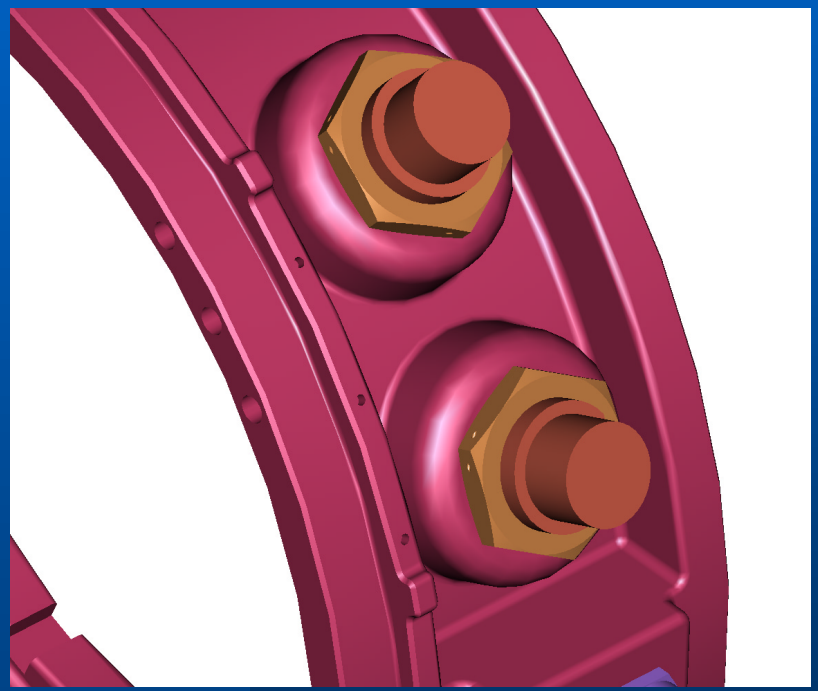
- The tool-less function of the windows is achieved by a part screwed the ACME screw with two D-handles that rotate out to allow installation.
- The D-handles snap into both the closed and open positions.

Interface Resource Ring



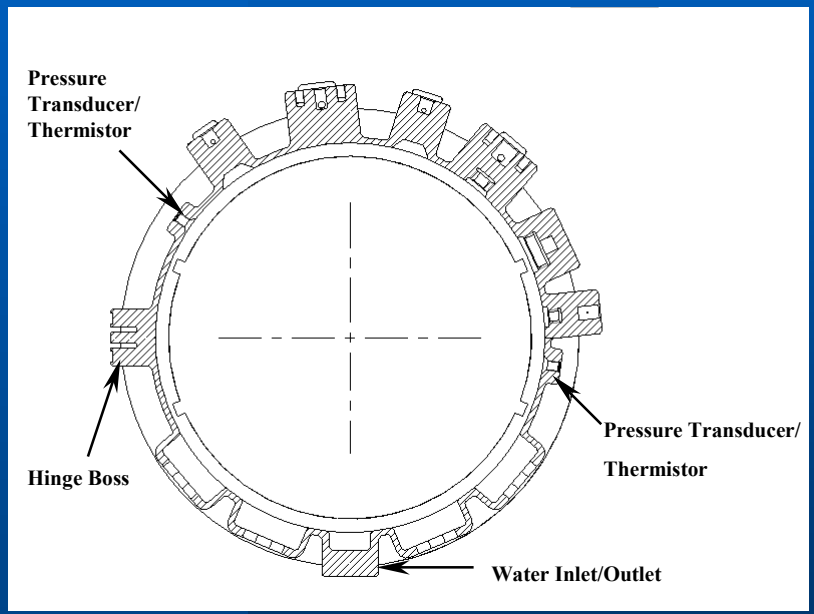
- The IRR is 284 mm at its maximum distance from its center and 175.5 mm long.
- The minimum internal diameter is 410 mm diameter and the maximum internal diameter is 440 mm.
- The minimum wall thickness is 6.5 mm.
- Notches are cut in the minor diameters to allow the CIA to chamber interface. This interface is allowed to extend over the IRR to protect the electrical connections and instrumentation.

Interface Resource Ring (continued)



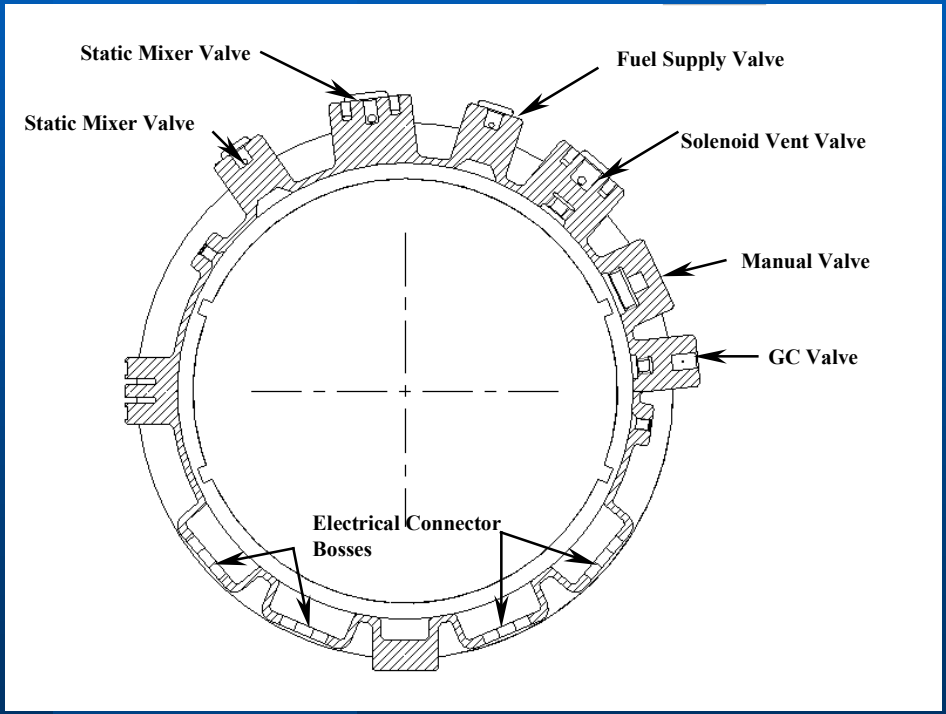
- The IRR has 36, M6 keenserts for attachment of the Window Section.
- A shelf is on the front end of the IRR is for the Kaydon bearing. Two protrusions located on this shelf act as hard stops to limit the breech lock rotation to 23°.
- Three holes located between the protrusions are used by pins on the Kaydon bearing to lock it in the open and closed position and to safe it in case of accidental opening of the chamber under pressure.

Interface Resource Ring (continued)



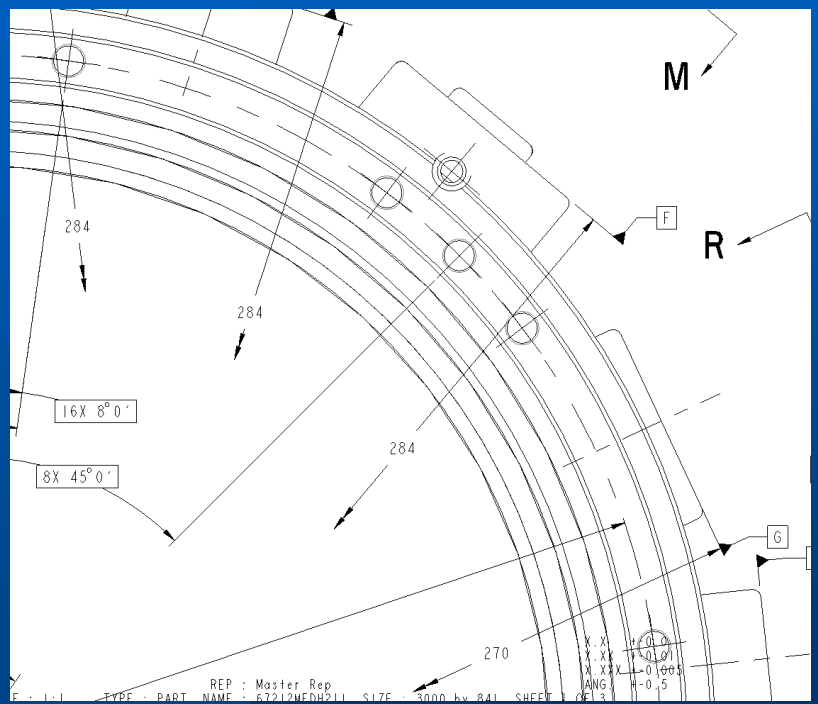
- The IRR has a large boss to which are attached the rails for the linear translation stage of the front end cap hinge at the 9 o'clock position.
- It has a boss at the 6 o'clock position in which the water inlet and outlet quick disconnects are installed.
- Bosses are located at the 3 o'clock and 10 o'clock positions to allow for the installation of a pressure transducer and thermistor in each.

Interface Resource Ring (continued)



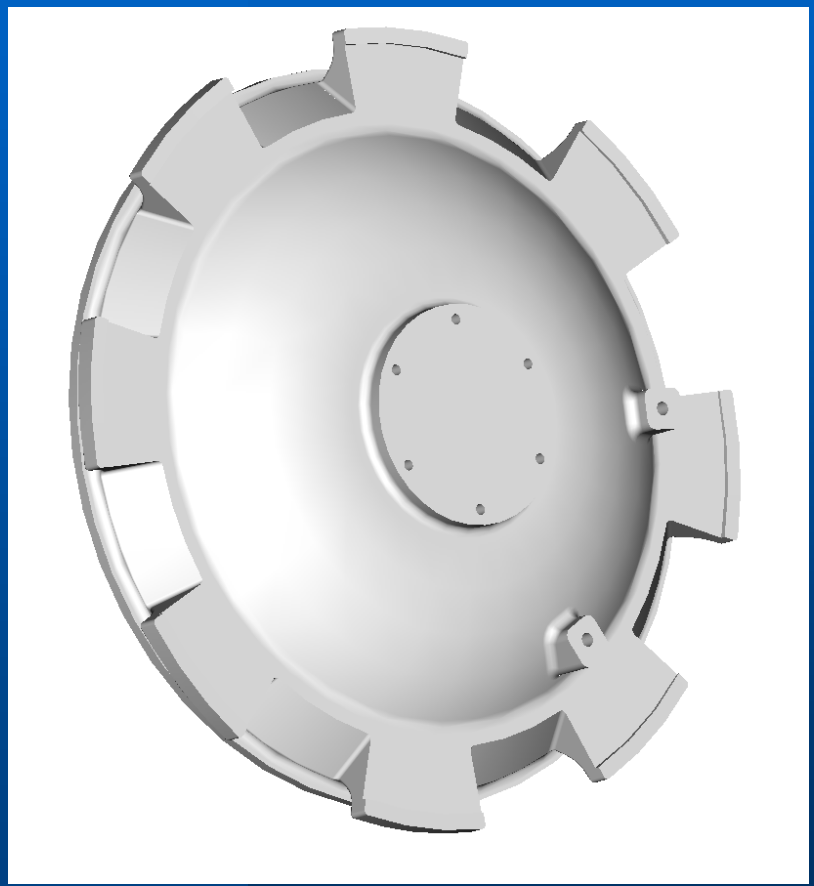
- Four bosses are located on the lower half of the IRR, two on either side of the water inlet/outlet. These bosses will be used to mount four feed-throughs for electrical connectors.
- Bosses exist clockwise froom the 3 o'clock position for:
  - ¼" GC valve
  - Manual vent valve
  - ½" Automatic Vent valve
  - ¼" Fuel supply valve
  - ½" Static mixer valve
  - ¼" High press. supply valve

Interface Resource Ring (continued)



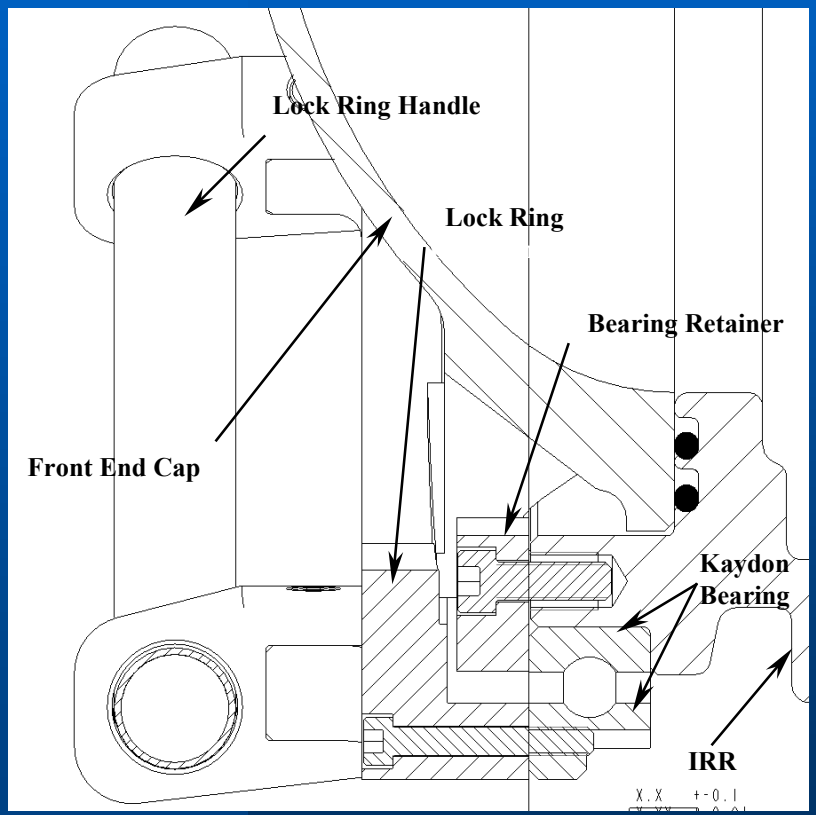
- A flat land is located inside the IRR at the front that contains two o-ring face seals. The seals were mandated by the phase 0/1 safety review.
- Keenserts for 24, M8 screws are located at the front of the IRR. These keenserts are used to clamp the bearing retainer to the IRR, trapping the Kaydon bearing between it and the IRR.

Front End Cap



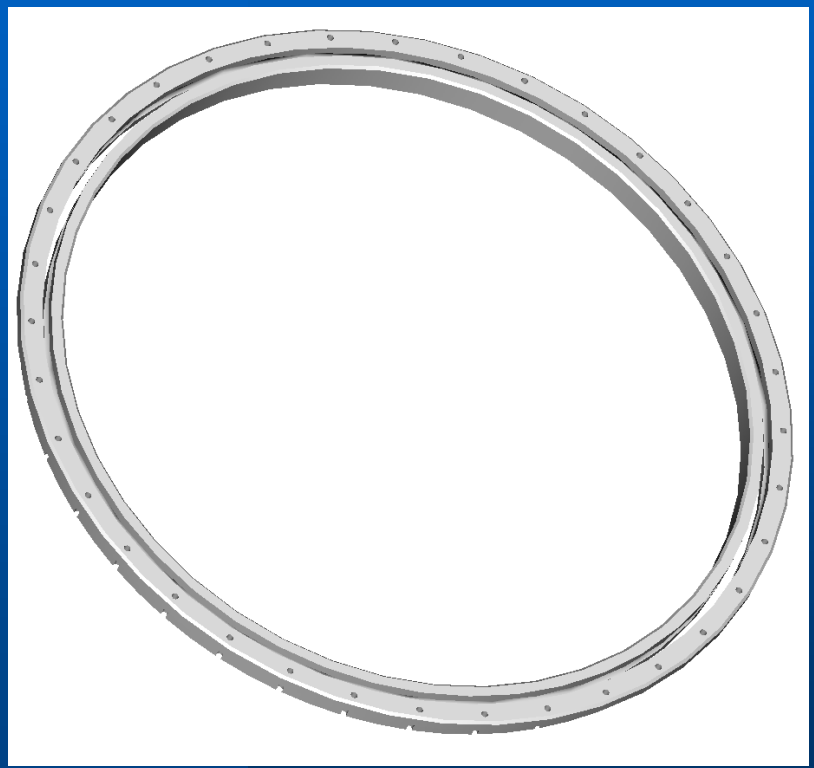
- The front end cap has a maximum external diameter of 507 mm. The diameter at the open end is 410 mm.
- A boss is located at the top of the front end cap to allow for the attachment of a support arm.
- Two other bosses are locate on the outside of the front end cap so that a handle can be attached.
- The front end cap has eight tabs with ramps that interface with a like ramp on the breech lock mechanism.

Breech Lock Mechanism



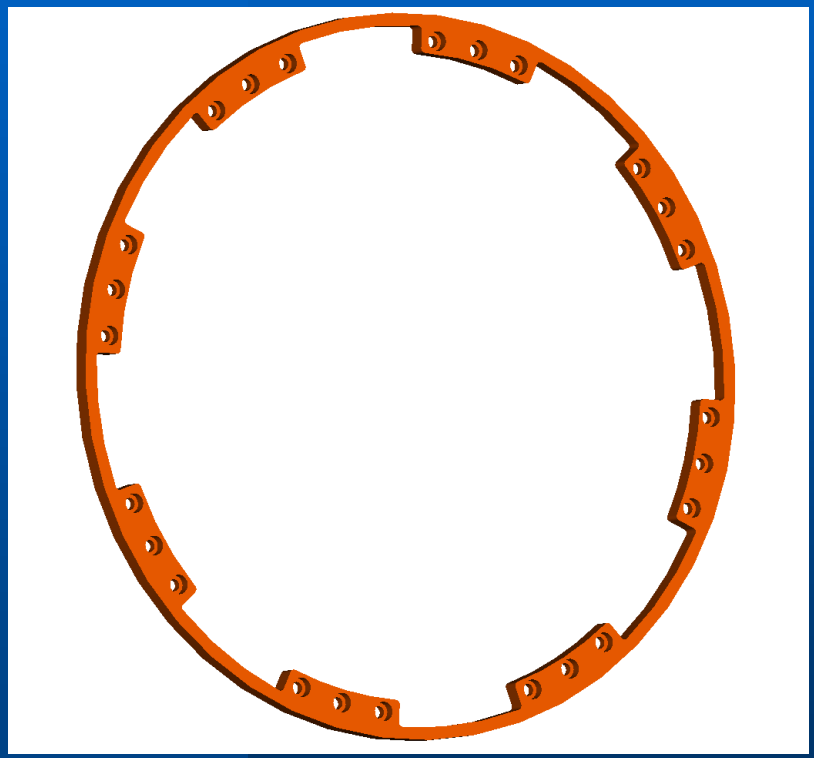
- Five major parts:
  - Bearing
  - Bearing Retainer
  - Locking Ring
  - Locking Ring Handle
  - Door Hinge
- All five parts work to allow the front end cap to seal and unseal without having to having to use tools or having to tether any part of the chamber assembly.

Breech Lock Mechanism (continued)



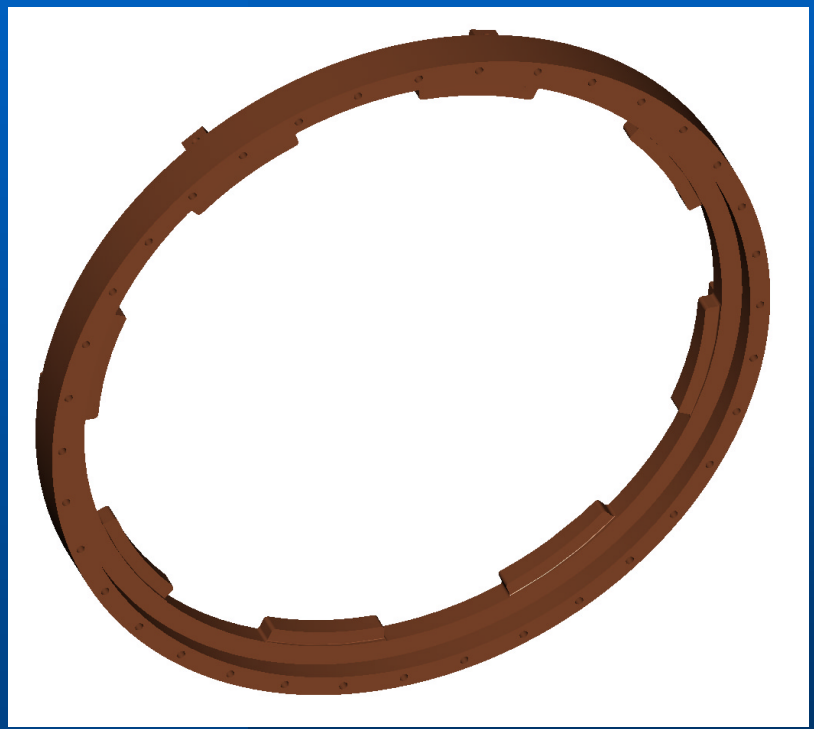
- The bearing is a 508 mm bore large diameter bearing.
- The inner race of the bearing is clamped to the IRR.
- The Locking Ring is attached to the outer race and is allowed to rotate 23°.
- The bearing can withstand 50000 lbs. of thrust load. The maximum thrust load expected is 37000 lbs. during qualification testing.

Breech Lock Mechanism (continued)



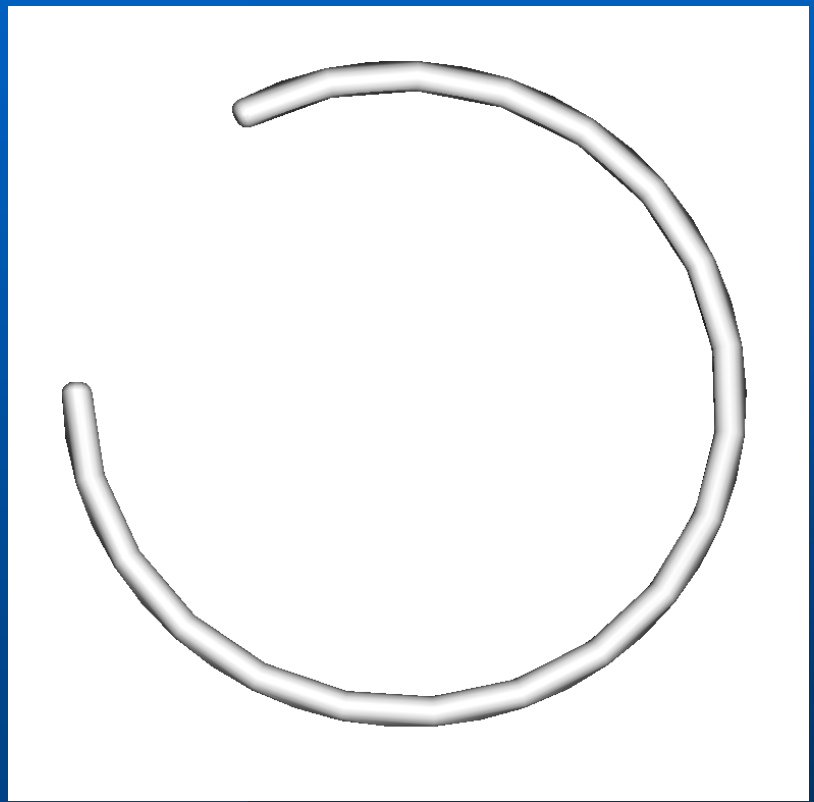
- The bearing retainer is used to clamp the inner race of the bearing to the IRR.
- The tabs on the bearing retainer are used to locate the front end cap and to lock it in place when installed.
- Three M8 per tab are used to attach the bearing retainer to the IRR. The screws were changed from M6's to M8's based on analysis.

Breech Lock Mechanism (continued)



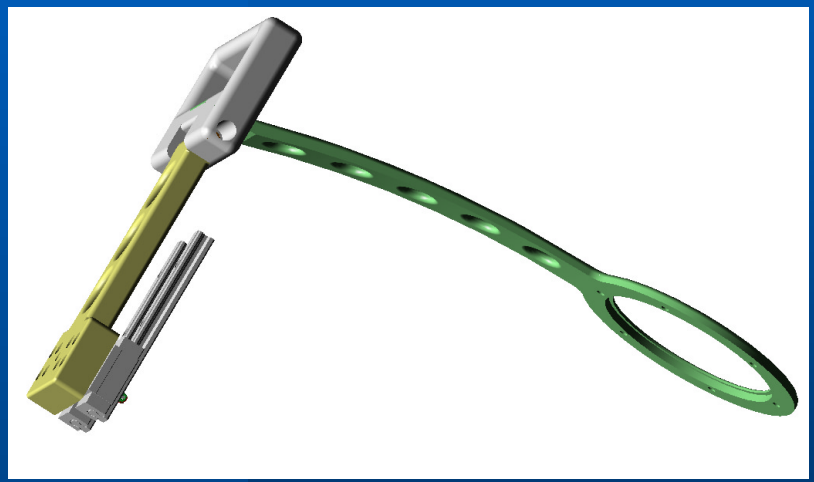
- The Locking Ring is a large aluminum ring used to clamp the front end cap to the IRR against the o-ring seals. The maximum diameter of the Locking Ring is 572 mm.
- It has eight tabs, each with a ramp that mates to the ramps on the front end caps tabs.
- Six bosses are located on top of the Locking Ring to allow for the attachment of a handle. Brackets are attached to connect the handle to the locking ring.

Breech Lock Mechanism (continued)



- The locking ring handle is a large hollow tube bent into a reverse “C” shape that is attached to the Locking Ring through six brackets.
- The tube is 1” in diameter with spherical ends. It is knurled to allow for better grip.
- The opening is to allow for the the support arm for the front end cap.

Breech Lock Mechanism (continued)



- The door hinge is composed of the support arm, the hinge handle, the linear translation stage, and the linear bearings.
- Two linear bearing rails are attached to the IRR. The linear bearings are attached to the linear translation stage. The linear translation stage is attached to the hinge handle by a hinge pin. The door support arm is attached to the hinge handle and the front end cap.

Analysis

- An analysis was performed on the entire chamber with particular attention paid to the breech lock mechanism.
- First pass analysis was completed on 9/98.
  - Recommended material change for front end cap and IRR from 6061-T6, to 7075-T73.
  - Results documented in “CIR Design Analysis Report”
- Second pass analysis is in progress
  - Breech mechanism and IRR remodeled due to design revisions.
  - Recommendations from the second pass are:
    - Increase the size of the screws holding the bearing retainer to the IRR from M6 to M8
    - Increase the thickness of the base of the front and rear end cap to reduce stress concerns
- Analyses pending
  - Fracture analysis
  - Window assembly analysis

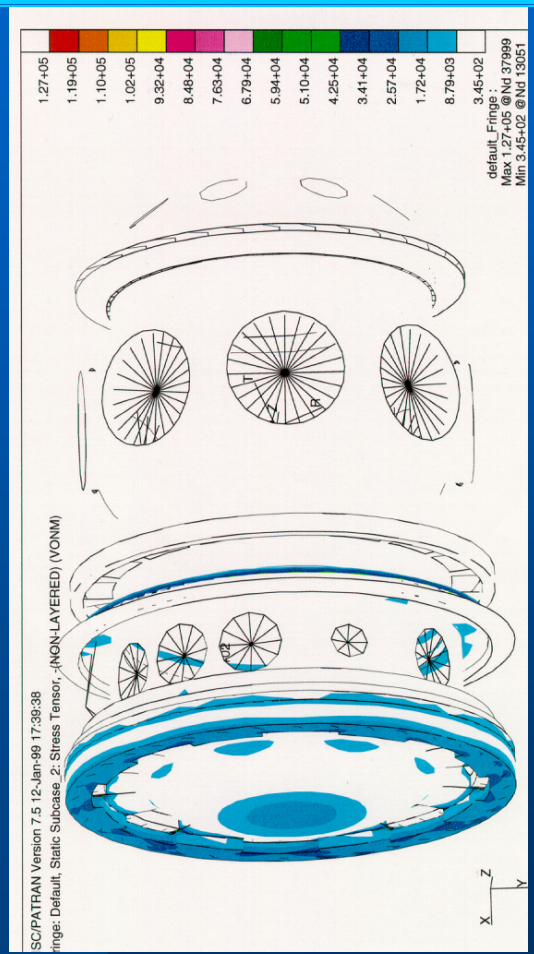
Analysis

- The stress plot to the left indicates the stresses are not a concern, but deflections at the center of the end cap are larger than expected due to very conservative modeling techniques at the flange interface of the end cap and the window section.

Analysis

- The stress plot at the left indicates high contact stress where the tabs on the front end cap meet the tabs on the lock ring. The stress rise at each end of the tab are a result of the modeling technique but do indicate that there will be higher contact stresses along the ramp of the tabs.

Analysis



- This stress plot (which picks up only solid elements) combined with the first plot (which picks up only shell elements) indicates that the general stress in the chamber when analyzed using two times MDP is relatively low.

Action Items